

# New Horizons in Solar System Exploration



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**JPL**

# The Solar System Exploration Program

... seeks answers to fundamental questions about the  
Solar System and life:

How do planets form?

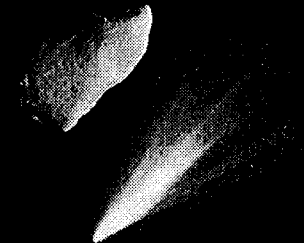
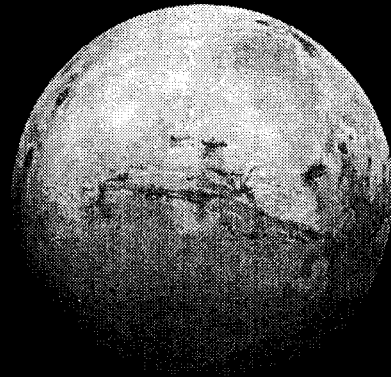
Why are planets different from one another?

Where did the makings of life come from?

Did life arise elsewhere in the Solar System?

What is the future habitability of Earth and other planets?

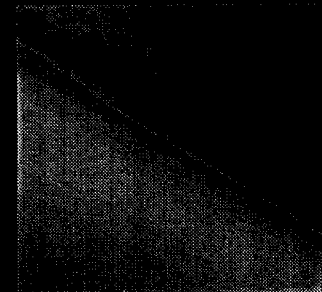
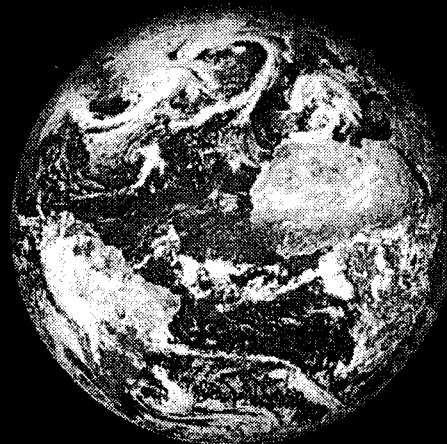
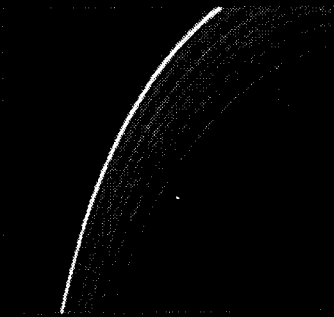
# The Search for Origins in Our Solar System



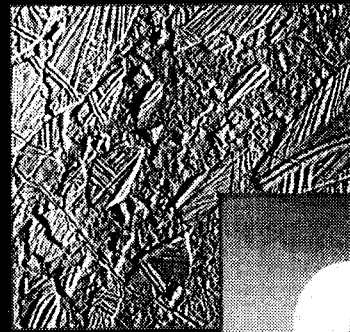
To answer these questions, the Solar System Exploration Program seeks to understand the Origins and evolution of

- the planets and other bodies of our solar system, including Earth;
  - environments habitable by any form of life; and
  - life itself,

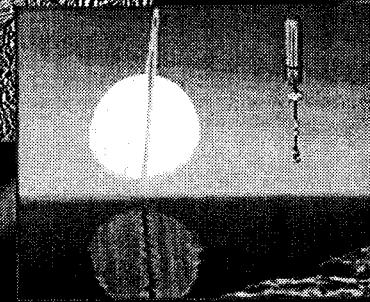
and how solar system processes affect the future of Earth and humanity.



# Outer Planets Program: Exploring Organic-Rich Environments

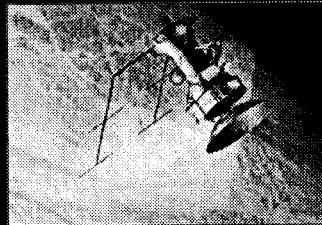


Europa  
Lander

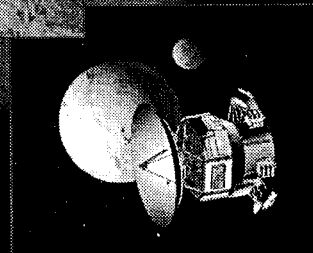


Titan  
Explorer

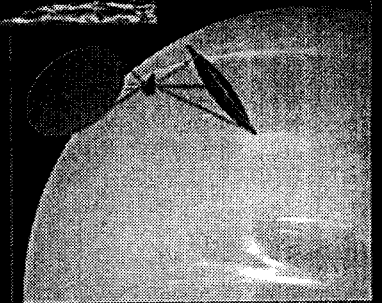
Europa Orbiter



Cassini/Huygens



Pluto/Kuiper Express



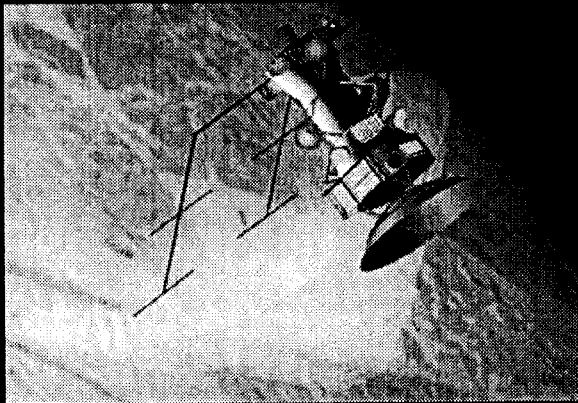
Neptune Orbiter



Galileo-Europa

# Exploring Organic-Rich Environments: Current Missions

## Europa Orbiter

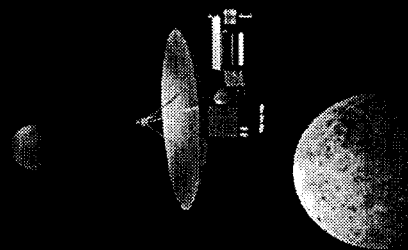


### *Key Questions:*

- Is there an ocean of liquid water beneath Europa's ice?
- Are there places where the ice is thin or where water reaches the surface?
- Could the Europa environment support pre-biotic chemical processes?

<b>Launch:</b>	<b>Nov 2003</b>
<b>At Jupiter:</b>	<b>2006</b>
<b>At Europa:</b>	<b>2008</b>

## Pluto-Kuiper Express

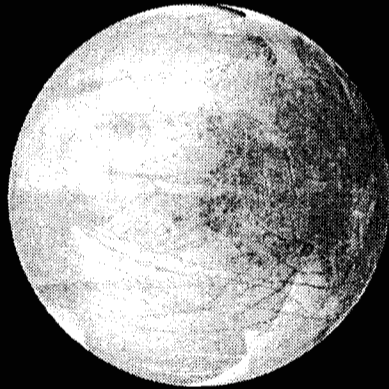


### *Key Questions:*

- What are the origins of Pluto, Triton, and the Kuiper Belt?
- What is the surface composition and atmospheric structure of Pluto and Charon?
- What is the organic inventory of the far outer solar system?

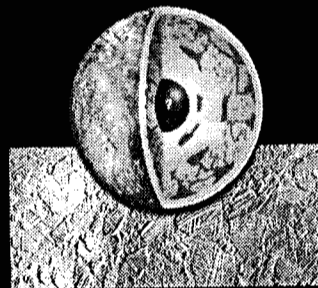
<b>Launch:</b>	<b>Dec 2004</b>
<b>At Pluto:</b>	<b>2014</b>

## Exploring Organic-Rich Environments: Europa Lander Mission



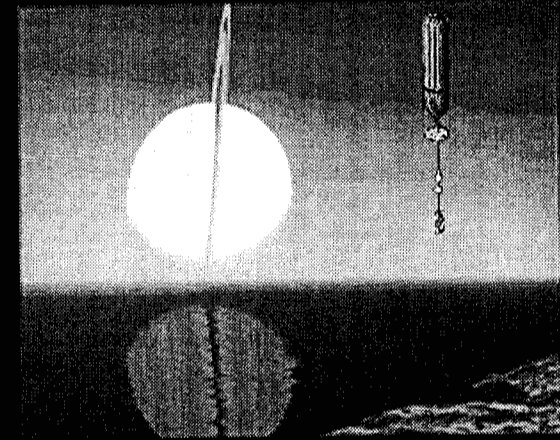
- **Critical Questions**

- What is the age and composition of the Europa surface?
- What organic chemical processes are taking place?
- Is there potential access to liquid water?
- Are there any indications of biological activity?



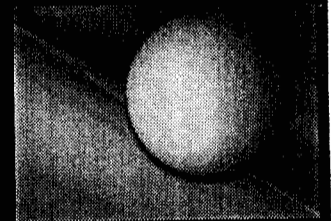
- Ready for mission start: 2005
- 6-8 year mission duration
- Technology demo of future subsurface access

## Exploring Organic-Rich Environments: Titan Explorer Mission



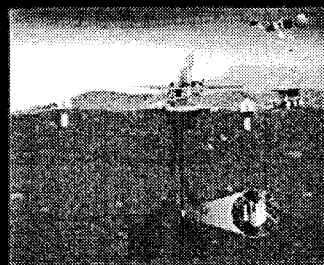
- **Critical Questions**

- What prebiotic chemistry is taking place at Titan and what can it tell us about the primordial Earth...and the origin of life?
- What is the composition of Titan's surface and how does it interact with the atmosphere?
- How has Titan evolved over its history?



- Ready for mission start: 2006-2007
- Atmospheric and surface measurements
- Balloon or aircraft for mobility

# Mars Surveyor Program: Bringing Mars to Earth



**Subsurface  
exploration**

**Earth-Mars Internet**



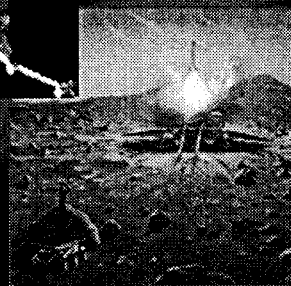
**Robotic Outposts**



**Sample  
Selection  
and In Situ  
Science**

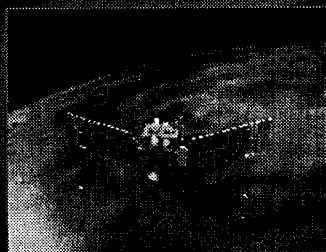


**Earth-based  
Laboratory  
Analysis**



**Sample  
Return**

**Climate  
Monitoring,  
Mapping/Site  
Selection  
Orbiters**

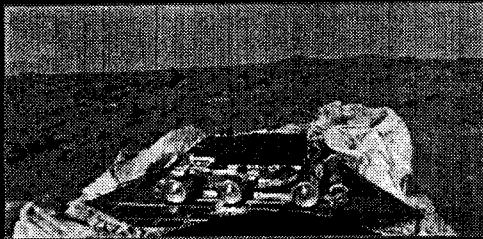


**Map Mineralogy,  
Volatiles, Geology**

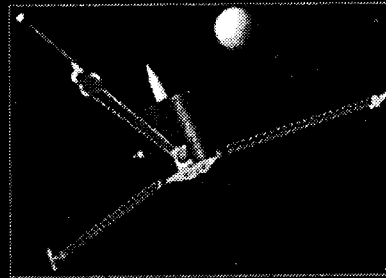
# Discovery Missions

*Accomplishments to date establish a firm, community-based foundation for solar system exploration and have exceeded all goals for technical performance, cost, and schedule*

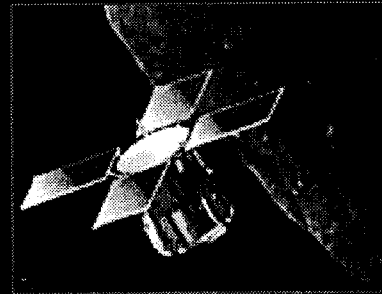
**Mars evolution:  
Mars Pathfinder**



**Lunar formation:  
Lunar Prospector**



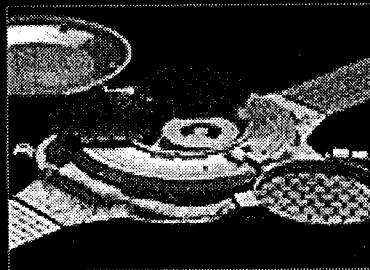
**NEO characteristics:  
NEAR**



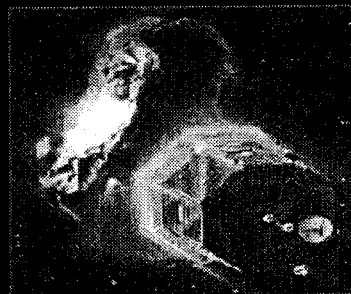
**Nature of dust/coma:  
Stardust**



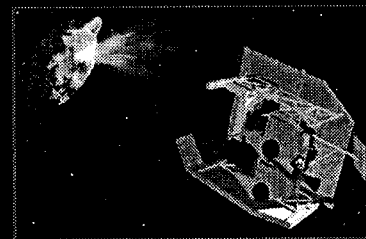
*Missions now in development will set new standards for increased capability within cost and schedule constraints*



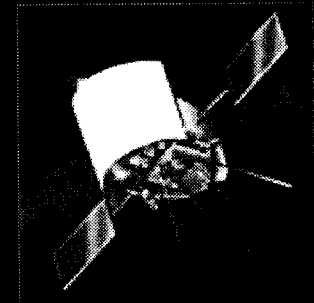
**Solar wind sampling:  
Genesis**



**Comet diversity:  
CONTOUR**



**Comet internal structure:  
Deep Impact**

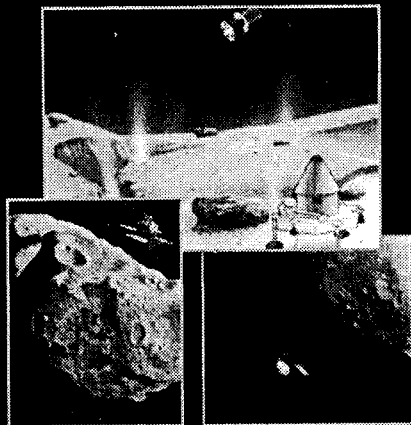


**Mercury environment:  
MESSENGER**

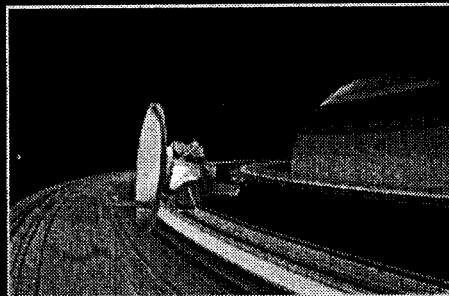
***Discovery: A Spring-board for Future Exploration***

# To Build a Planet..

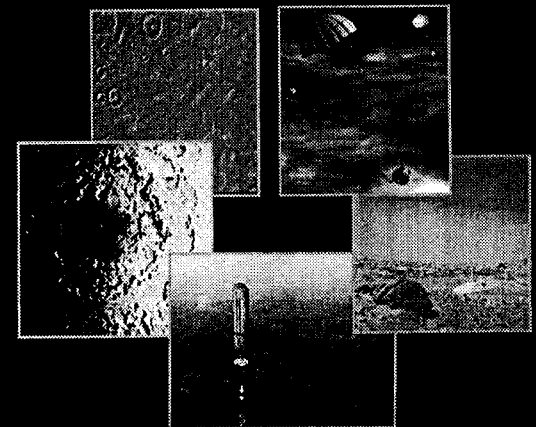
Building Blocks



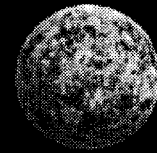
Dynamic Processes



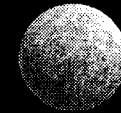
Diverse Outcomes



Venus



Mercury



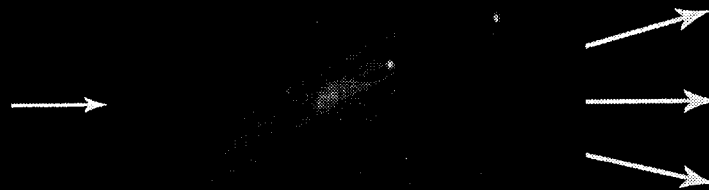
Mars



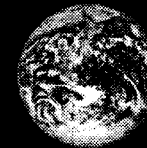
Moon



Giant Planets



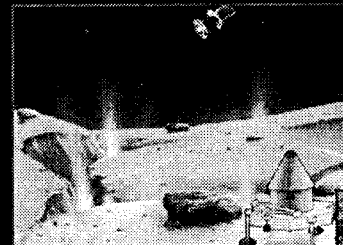
Earth



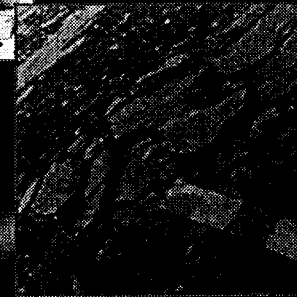
# To Build a Planet:

## Formation and evolution of planetary environments

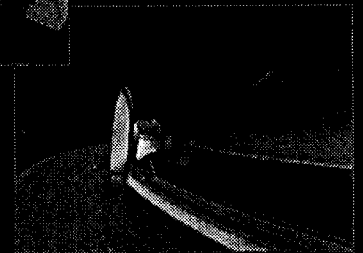
Comet Nucleus  
Sample Return



Venus  
Sample Return



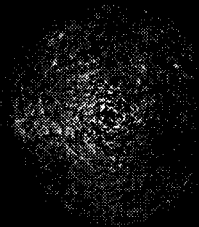
Saturn Ring  
Observer



MESSENGER



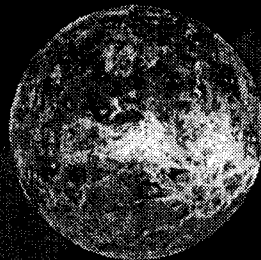
Lunar Prospector



Primitive Bodies Missions



Magellan



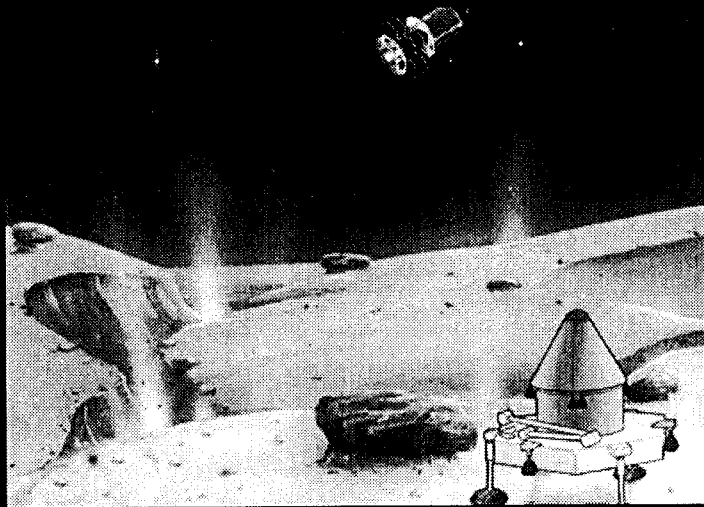
Mars Surveyor



Mars Surveyor



# To Build a Planet: Comet Nucleus Sample Return



- **Critical Questions:**

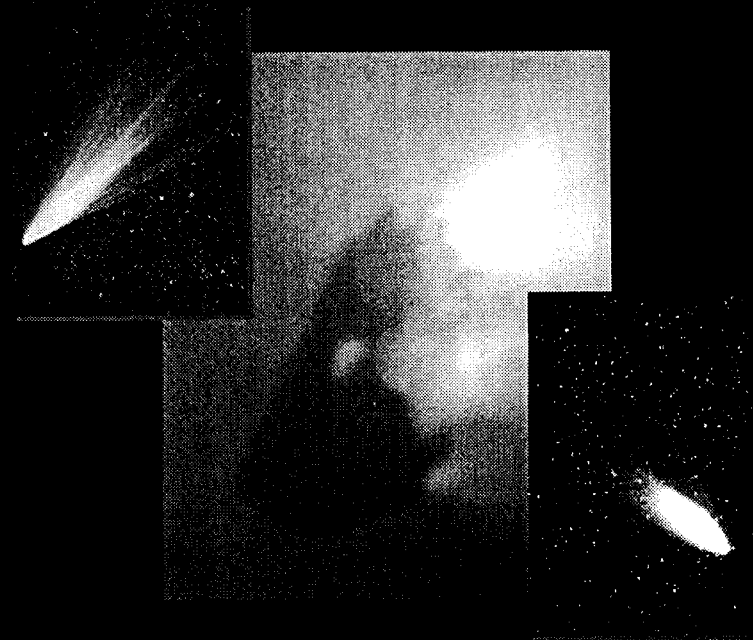
- What is the chemical composition of pristine comet nucleus material? What does it tell us about the primordial solar system?
- How have comets evolved since their formation? How does their composition vary with depth and location on the nucleus?
- What can we learn about the likely effects and mitigation of cometary impacts?

- Ready for mission start: 2002-2003
- Mission duration 6 to 10 yrs
- Launch opportunities every year

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- **Key Capabilities**

- Comet sample acquisition and handling
- Improved solar electric propulsion
- Autonomous control and navigation
- High-efficiency solar arrays
- Micro organic chemistry laboratory
- High velocity Earth entry system



# To Build a Planet: Venus Surface Sample Return



- **Critical questions**

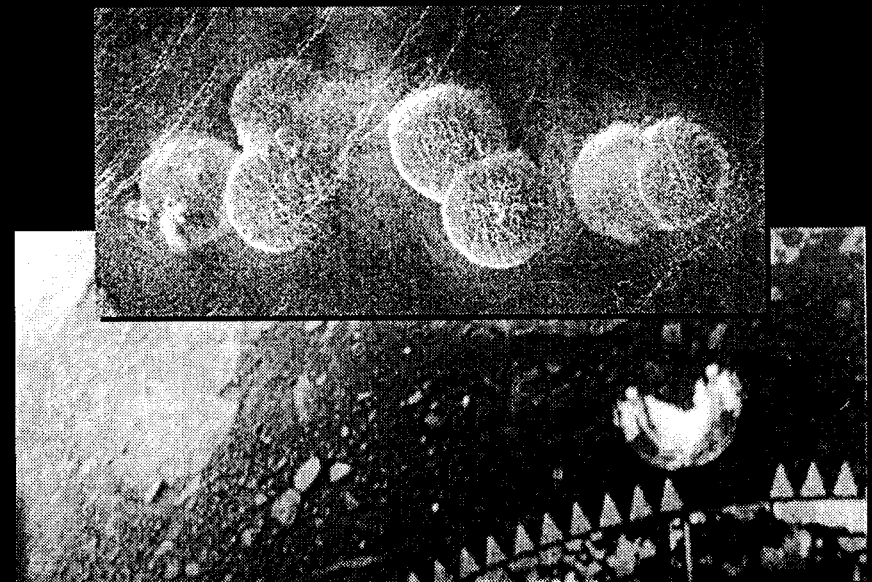
- What is the age and chemical composition of Venus' surface? What is its atmospheric composition?
- Why did Venus and Earth take such different evolutionary pathways?
- Was there ever liquid water on Venus? Where did it go?
- What can Venus tell us about the future of planet Earth?

- Ready for mission start: 2006-2007
- Short-duration surface stay time (~90 min)
- Balloon/rocket ascent
- Significant use of Mars Sample Return technologies

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- **Key Capabilities**

- Aerocapture
- High temperature balloon system
- Thermal control
- Sampling mechanisms



# Summary of Recommendations

*Near-term and Mid-term\**  
(2003-2007) (2008-2013)

*Far-term*  
(2013 and beyond)

Top New  
Priority

*Mars Sample  
Handling and Analysis*  
Mars Subsurface Exploration  
Mars Robotic Outposts  
Earth-Mars Internet

## Mars Surveyor Program (Continuing)

Intensive site exploration  
Advanced outposts  
Deep coring and search for extant life

## Outer Planets Program (Continuing)

Europa Lander  
Titan Explorer  
Neptune Orbiter/Triton Flybys

Robotic outposts and sample returns  
Kuiper Belt exploration  
Interstellar precursors

## Discovery Program (Continuing)

Competitively Selected Missions

Advanced Studies of Planet  
Formation and Evolution

## To Build a Planet (Proposed new program)

*Comet Nucleus  
Sample Return*  
Venus Sample Return  
Saturn Ring Observer

Top Priority  
New Mission

Sample all types of bodies  
Deep atmospheric probes  
Explore large asteroids/protoplanets

\* Approximate mission start dates

# **Summary: Key Capabilities for Recommended Missions**

## **Mission**

## **New System Capabilities**

**Comet Nucleus Sample Return**

Advanced propulsion  
Earth entry vehicle

**Europa Lander**

Organic chemistry lab  
Airless body lander  
Bioload reduction

**Titan Explorer**

Atmospheric mobility  
Aerocapture  
Organic chemistry lab

**Neptune Orbiter and Saturn Ring Observer**

Advanced propulsion  
Aerocapture  
Micro-avionics and autonomy

**Venus Surface Sample Return**

Atmospheric mobility and descent  
Survivability  
Aerocapture

**Mars Surveyor and Robotic Outposts**

Telecom network and optical comm  
Subsurface access and sounding  
Atmospheric mobility  
Autonomous cooperating explorers

# Solar System Exploration Missions

